Amir-Reza Negari

Updated 28 October 2026

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Academic Background

Postdoctoral Fellow 2026–present
Institute for Quantum Computing, University of Waterloo.
Quantum Interactions Theory Group; supervisor: Christine Muschik.

Ph.D. in Physics, University of Waterloo 2022–2026
Research at Perimeter Institute for Theoretical Physics.
Supervisors: Timothy H. Hsieh and Roger G. Melko.
Thesis: *Phases of matter in quantum information and error correction*.
Information-theoretic diagnostics of phases and transitions in quantum systems subject to noise and measurement.

M.Sc. in Physics, University of Waterloo 2021–2022
Perimeter Scholars International (PSI), Perimeter Institute.
Advisor: Timothy H. Hsieh. Master's essay: *Measurement-induced phase transitions*.

B.Sc., Sharif University of Technology 2016–2021
Advisor: Abolhassan Vaezi.

Awards and Recognition

Editors' Suggestion, Physical Review Letters 2022
Chiral Ising Gross–Neveu Criticality of a Single Dirac Cone: A Quantum Monte Carlo Study.
Joint first author with S. Mojtaba Tabatabaei; *Physical Review Letters* **128**, 225701.

Bronze Medal, International Physics Olympiad 2016
47th International Physics Olympiad, Zurich, Switzerland.

Gold Medal, Iran's National Physics Olympiad 2015
Included exemption from the final year of high school and the national university entrance examination.

Fellowships and scholarships

Institute for Quantum Computing fellowship
International student scholarship, University of Waterloo 2022–2026
Perimeter Residence Scholarship 2022–2026
Perimeter International Scholarship 2021–2022

Computational Methods and Software

Programming: Python (JAX, PyTorch, CuPy, Numba CUDA); C/C++; CUDA; Julia; MATLAB.

Scientific computing: GPU and CPU parallel programming; distributed and high-performance computing; Slurm.

Numerical and analytical methods: Tensor networks, density-matrix renormalization group (DMRG) and matrix product states (MPS); determinantal quantum Monte Carlo; Clifford and stabilizer methods; fermionic and bosonic Gaussian formalisms; quantum error-correction decoders, including minimum-weight perfect matching and belief propagation.

Publications and Preprints

Six peer-reviewed articles and seven preprints, listed separately below.
* Equal contribution.

Peer-reviewed articles

1. **Symmetry enforcing entanglement at high temperatures**
   Amir-Reza Negari*, Leonardo A. Lessa*, Subhayan Sahu.
   Physical Review A **114**, 022458 (2026). arXiv:2508.20166
   Conditions under which symmetry and superselection rules preserve thermal entanglement at arbitrarily high temperatures.

2. **Extendibility of Fermionic Gaussian States**
Amir-Reza Negari, Farzin Salek.
Physical Review Letters **137**, 080201 (2026). arXiv:2508.18532
Covariance-matrix tests for extendibility and quantitative bounds on proximity to separable states.
3. **Spacetime Markov length: A diagnostic for fault tolerance via mixed-state phases**
Amir-Reza Negari, Tyler D. Ellison, Timothy H. Hsieh.
Physical Review B **114**, 045130 (2026). arXiv:2412.00193
A decoder-independent diagnostic of fault tolerance using conditional mutual information in repeated syndrome measurements.
4. **Measurement-induced phase transitions in the toric code**
Amir-Reza Negari, Subhayan Sahu, Timothy H. Hsieh.
Physical Review B **109**, 125148 (2024). arXiv:2307.02292
Connections between single-qubit measurements, Gaussian tensor networks and classical loop models.
5. **Chiral Ising Gross–Neveu Criticality of a Single Dirac Cone: A Quantum Monte Carlo Study**
S. Mojtaba Tabatabaei*, **Amir-Reza Negari***, Joseph Maciejko, Abolhassan Vaezi.
Physical Review Letters **128**, 225701 (2022). arXiv:2112.09209
Editors' Suggestion.
Monte Carlo simulations and finite-size scaling of the transition from a Dirac semimetal to a ferromagnetic insulator.
6. **Amelioration for the Sign Problem: An Adiabatic Quantum Monte Carlo Algorithm**
Mohammad-Sadegh Vaezi, **Amir-Reza Negari**, Amin Moharramipour, Abolhassan Vaezi.
Physical Review Letters **127**, 217003 (2021). arXiv:2012.12911
An adiabatic Monte Carlo approach to reducing the sign problem in interacting-fermion simulations.

Preprints

7. **Instability of Markov chains under infinitesimal coherent dissipation**
Amir-Reza Negari, Yijian Zou, Timothy H. Hsieh.
arXiv:2610.18983, 13 October 2026.
Local dissipative dynamics that generate infinite Markov length in arbitrarily short time.
8. **Nonadditivity in fermionic quantum Shannon theory**
Farzin Salek, **Amir-Reza Negari**, Graeme Smith, Jens Eisert, Debbie Leung.
arXiv:2610.06758, 5 October 2026.
Nonadditivity of fermionic entanglement of formation, minimum output entropy and Holevo information, with channel-capacity results.
9. **Entanglement of purification for Werner states: canonical purification and nonadditivity**
Zahra Baghali Khanian, **Amir-Reza Negari**.
arXiv:2610.03630, 2 October 2026.
Exact entanglement-of-purification results for a range of two-qubit Werner states and a proof of nonadditivity.
10. **Approximation theorems for fermionic Gaussian states**
Amir-Reza Negari, Farzin Salek, Zoltán Zimborás, Aram Harrow, Patrick Hayden, Jens Eisert.
arXiv:2610.01860, 1 October 2026.
Product-state, de Finetti and recovery approximations based on Majorana covariance matrices.
11. **Rényi Entanglement of Purification Is Non-additive**
Amir-Reza Negari, Zahra Baghali Khanian.
arXiv:2608.28897, 28 August 2026.
One-copy optimization and two-copy nonadditivity examples for classical two-qubit states.
12. **Unlearnable phases of matter**
Tarun Advaith Kumar, Yijian Zou, **Amir-Reza Negari**, Roger G. Melko, Timothy H. Hsieh.
arXiv:2602.11262, 11 February 2026.
Connections between conditional correlations and the difficulty of learning noisy-code distributions.
13. **Critical non-equilibrium phases from noisy topological memories**
Amir-Reza Negari, Subhayan Sahu, Jan Behrends, Benjamin Béri, Timothy H. Hsieh.
arXiv:2601.10792, 15 January 2026.
A critical mixed-state phase retaining partial logical information recoverable by a global decoder but not by any quasi-local decoder.

Talks and Posters

Seminars

Critical Mixed-State Phases from Coherent Errors: CMI, Loop Constraints, and Network Conductance 11 Nov 2025
Condensed Matter Theory Seminar, University of Cologne; online. Announcement

Fault tolerance via mixed-state phases 3 Feb 2025
Perimeter Institute for Theoretical Physics. Recording

Classical simulability of MBQC and measurement-induced transitions in the toric code 2023
Invited talk, University of British Columbia. Host: Robert Raussendorf. MBQC: measurement-based quantum computation.

Measurement-induced phase transitions in the toric code 15 May 2023
Perimeter Institute for Theoretical Physics. Recording

Conference and group presentations

Extendibility of Fermionic Gaussian States 7 Oct 2025
Contributed talk, Year of Quantum Across Canada, Institute for Quantum Computing, Waterloo. Programme

PSI 2021 cohort project 20 Jun 2024
Group presentation, PSI 15th Anniversary Reunion, Perimeter Institute.
Programme: *Merging space and time for fault-tolerance*.
Recording: *Frustration-free monitored dynamics beyond the stabilizer framework*.
Project team: Amir-Reza Negari, Jacob Hauser, Dongjin Lee, Leonardo Lessa, Neel Modi, Sydney Timmermann and Jinmin Yi.

Measurement-induced phase transitions in the toric code 7 Mar 2024
Contributed talk, APS March Meeting, Minneapolis. Session W14: Measurement-Induced Phase Transitions. Programme

Posters

Spacetime Markov length: a diagnostic for fault tolerance via mixed-state phases 11–15 Aug 2025
QUDYN25, Max Planck Institute for the Physics of Complex Systems, Dresden. Programme

Measurement-induced phase transitions in the toric code 2023
Boulder Summer School, University of Colorado Boulder. Participant profile

Teaching and Mentoring

Student mentoring

Perimeter Scholars International 2023–2025
Mentored a student in PSI, Perimeter Institute's intensive one-year master's programme in theoretical physics, leading to an M.Sc. from the University of Waterloo.

International Summer School for Young Physicists (ISSYP)
Supervised a group research project for high-school students at Perimeter Institute. ISSYP is a two-week programme introducing Canadian and international students to modern physics and research through lectures, activities and mentoring.

Teaching assistantships

Statistical Physics (M.Sc.); instructor: Sidney Redner. Fall 2022
Quantum Mechanics II (undergraduate); instructor: Abolhassan Vaezi. Spring 2021
Quantum Mechanics I (undergraduate); instructor: Abolhassan Vaezi. Fall 2020
Thermodynamics II (undergraduate); instructor: Vahid Karimipour. Fall 2019
Thermodynamics I (undergraduate); instructor: Vahid Karimipour. Spring 2019
Mathematical Physics I (undergraduate); instructor: Laleh Memarzadeh. Spring 2018

Physics Olympiad instruction and outreach

Thermodynamics instructor, Young Scholars Club 2019
Taught thermodynamics for Physics Olympiad training. The club runs Iran's national scientific Olympiads for the Ministry of Education, selecting top students through nationwide competitions and training Iran's teams for international Olympiads.

Physics Olympiad instructor and laboratory tutor 2015–2018

Taught mechanics, electrodynamics, problem solving and laboratory work at Salam, Farzanegan, Tabatabaei and Alborz high schools in Iran.
These include Farzanegan, part of the national gifted-education network (NODET/SAMPAD); Alborz, a historic Tehran school with roots in 1873; and the Salam and Allameh Tabatabaei school networks, whose students have earned national and international Olympiad medals.

Academic Service

Peer review

- Quantum Information Processing (QIP) conference: reviewer, 2026 and 2027.
- *PRX Quantum*: referee.
- *Physical Review B*: referee.

Research community and seminar organization

- Founded and organized the **Eureka Club** at Perimeter Institute for graduate students and postdoctoral researchers.
- Co-founded and organized the **Topological Quantum Club** at Perimeter Institute for graduate students and postdoctoral researchers.
- Founded and organized a **biweekly arXiv lunch** for the Quantum Matter group at Perimeter Institute.